Evaluate the effectiveness of JOBST® compression stockings for fluid redistribution in the lunar bed rest analog based on Digital Astronaut computer model predictions.

Background
NASA’s future goals include missions to the moon which will require extended exposure to the lunar gravity (1/6 Earth gravity) environment. To prepare for these missions, physiological adaptations in various systems must be resolved. We have used bed rest at a 10º head-up tilt to simulate lunar gravity.

Plasma volume (PV) loss may cause some of the cardiovascular adaptations which occur during space flight so PV is measured in the in bed rest analog to evaluate fluid loss1,2. Plasma volume varies from individual to individual so PV is measured in the bed rest analog to evaluate fluid magnitude and time course of fluid shifts and cardiovascular adaptations which occur during space flight and thigh-high (n = 11) JOBST® stockings (Rutherford College, NC) were worn from 6am to 10pm. Efficacy of the stockings was determined by the average PVI (Plasma Volume/Body Surface Area) which most closely approximated the Digital Astronaut model prediction. A two-sample student t-test assuming equal variances was used to determine the difference between the two stocking types.

Methods
Three days prior to the first day of testing, subjects (n = 13) were admitted to the bed rest unit and placed on a controlled diet. PV was measured by the carbon monoxide rebreathing technique4. Baseline PV was measured at 6pm one day prior to beginning bed rest (BR-1). Subjects remained at a 10º head-up position for 6 days followed by a second PV measurement at 6pm (BR+6). Knee-high (n = 2) and thigh-high (n = 11) JOBST® stockings (Rutherford College, NC) were worn from 6am to 10pm. Efficacy of the stockings was determined by the average PVI (Plasma Volume/Body Surface Area) which most closely approximated the Digital Astronaut model prediction. A two-sample student t-test assuming equal variances was used to determine the difference between the two stocking types.

Results
Overall, PVI is decreased by 13.35% ± 3.14 (mean ± SE) during head-up bed rest. The knee-high stockings (n = 2) resulted in a PVI decrease of 3.92% ± 11.15 while the thigh-high stockings decreased plasma volume by 15.07% ± 3.13. There was not a significant difference between the two stocking types (p = 0.21).

Conclusions
PVI losses confirm the value of this model of lunar gravity for fluid shifts predicted by the Digital Astronaut. There were no statistical differences between stocking types. Subject comfort and compliance were enhanced by use of the knee-high stockings; therefore, knee-high stockings will be used in further lunar bed rest studies. Larger amounts of fluid were lost than expected which may have been due to the amount of compression; the stockings were originally designed for ambulatory patients needing compression to aid in cardiovascular circulation dysfunction. Additionally, diet was only controlled for three days prior to bed rest which may have contributed to differences from predicted values.

Future Studies
These measurements were a part of the Lunar Analog Feasibility Study (LAFS), therefore, a limited number of subjects have been evaluated. Additional subjects in bed rest over longer durations will provide a better perspective of fluid shifting and associated plasma volume loss in simulated lunar gravity. The compression of the stockings will be decreased to further emulate the expected 6% plasma volume loss.

There is no substitute for actual spaceflight data. It will be ideal to obtain lunar gravity plasma volume data from spaceflight studies when NASA returns astronauts to the moon after 2020. The lunar bed rest model will not be fully validated until 2025 or 2030 as it is unlikely lunar missions will increase to 60 days soon after the first few lunar landings.

References

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